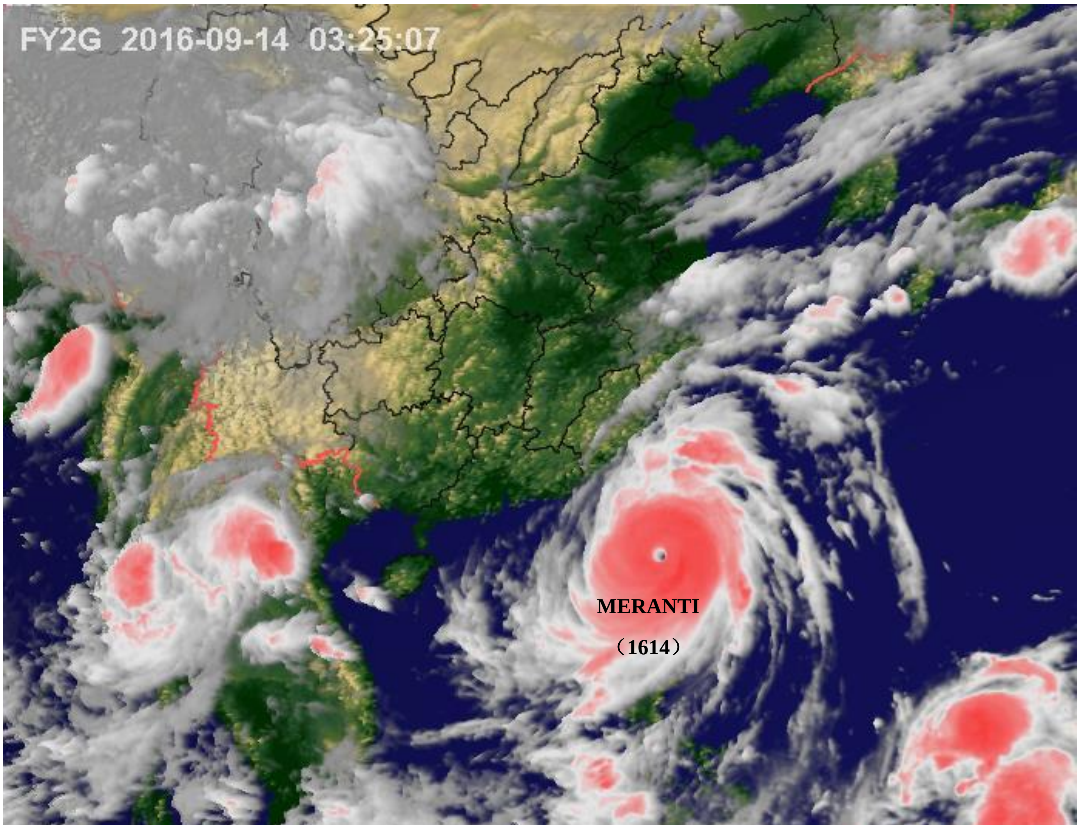
MEMBER REPORT

(2016)

ESCAP/WMO Typhoon Committee

11th Integrated Workshop

China



October 24-28, 2016

Cebu, Philippines

Contents

I. Review of Tropical Cyclones Which Have Affected/Impacted Members since the Previous Session

1.1 Meteorological and hydrological assessment

During January-May of 2016, SST anomalies became steadily weakened in the central and eastern part of the Equatorial Pacific, characterizing an attenuated El Nino. Meanwhile, the Indian Ocean witnessed noticeably warmer SST. Thanks to the concerted effects of a decayed El Nino event and a warmer Indian Ocean, the anti-cyclonic anomalies in the northwestern Pacific were encouraged to stay longer, which in turn dampened typhoon activities over the northwestern Pacific and the South China Sea. During the summer since June, the central Equatorial Pacific remained cold compared with a warm Western Pacific in the tropics and Indian Ocean with a de-escalated warming process. As a result, the northwestern Pacific reported significantly enhanced typhoon activities since late July, compared with the preceding period.

During the period from January 1 to October 22 of 2016, the northwestern Pacific and the South China Sea registered the genesis of 22 tropical cyclones, including tropical storm, severe tropical storm, typhoon, severe typhoon and super typhoon. Of them, 8 tropical cyclones made landfall in China’s coastal areas, including super typhoon NEPARTAK (1601), tropical storm MIRINAE (1603), severe typhoon NIDA (1604), severe tropical storm DIANMU (1608), super typhoon MERANTI (1614), severe typhoon MEGI (1617), super typhoon SARIKA (1621) and super typhoon HAIMA (1622).

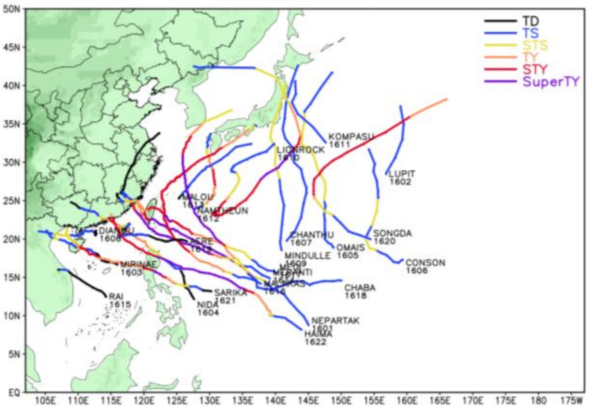


Fig. 1.1. Tracks of tropical cyclones in 2016.

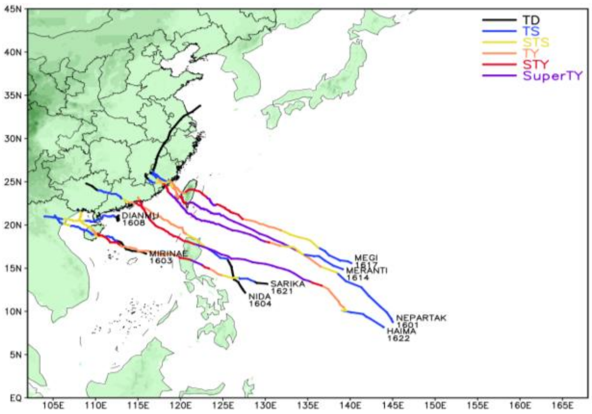


Fig. 1.2. Tropical cyclones making landfall in 2016.

1.1.1 Characterization of tropical cyclones occurred in 2016

1) No TC genesis in the first half of this year.

During January-June of 2016, no typhoon incidences were registered across the northwestern Pacific and the South China Sea, or 4.6 incidences less compared with the same period of a normal year.

2) Late genesis of the first typhoon

NEPARTAK, the number one typhoon in this year makes the second latest typhoon genesis in history (since 1949) in terms of its debut timing. It was named on July 3, compared with Typhoon NICHOLE that was coded on July 9 as the first typhoon in 1998.

3) More landing TCs

As of October 22, 2016, 8 typhoons made landfall over China, or 1.3 more compared with 6.7 incidences in the same historical period.

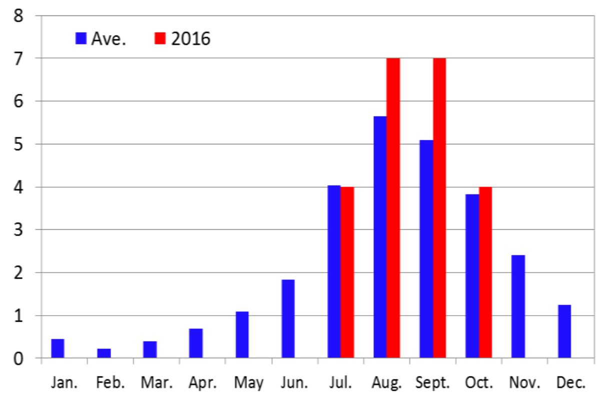


Fig. 1.3. Monthly averaged TC genesis and monthly TC genesis in 2016.

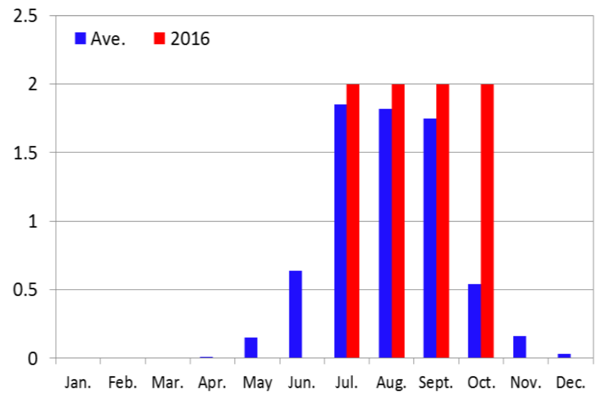


Fig. 1.4. Monthly averaged landing TCs and monthly landing TCs in 2016.

4) Northerly and easterly TC origins

Tropical cyclones would habitually make their debut in three major areas on the northwestern Pacific and the South China Sea: 1) the central and northern part of the South China Sea; 2) the waters east of the Philippines; and 3) the waters nearing the Mariana Islands. However, this year typhoon made their debut slightly northerly in position. Meanwhile, the tropical cyclones that appeared in the east of the Philippines were dwindled in number. Many tropical cyclones were generated near the Mariana Islands, making the average genesis position slightly easterly (Figure 1.5).

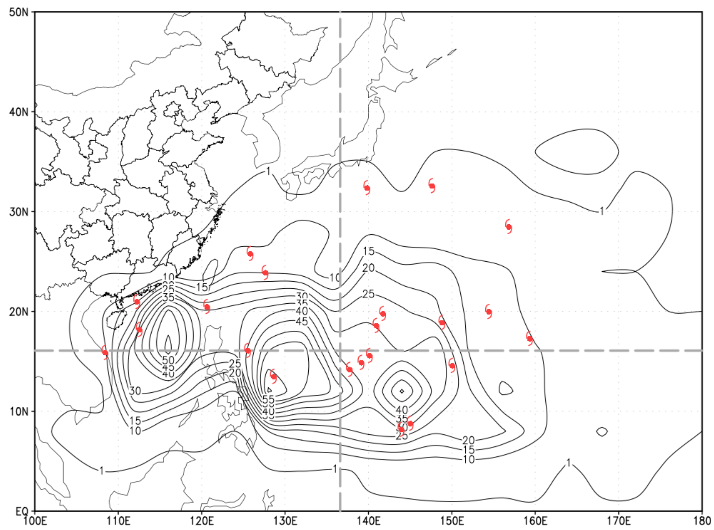


Fig. 1.5 Distribution of tropical cyclone origins on the northwestern Pacific and the South China Sea, 1949-2015 (incident/πR^2, R = 250 km), and the location of tropical cyclones generated during Jan. 1–Oct. 22 of 2016.

5) Southerly landfall sites

In 2016, 8 tropical cyclones made landfall over China with different intensity. Anyway, the landfall sites of the 8 tropical cyclones are located in Fujian, or further to the more south coasts, that makes the average landfall site slightly southerly. (Figure 1.2).

6) High landfall intensity

The averaged landfall intensity of 8 landfall typhoons was 40.6m/s, which is higher than the multi-year average of 32.8m/s.

1.1.2 Forecast operations

Over the past five years (2012-2016), the CMA official typhoon track forecast errors maintained a descending trend. As of October 22, 2016, the 24-120-hour typhoon track forecast errors were at 66, 125, 202, 284 and 379 km, respectively. The 24-hour track forecast error has been kept within 70 km in two consecutive years.

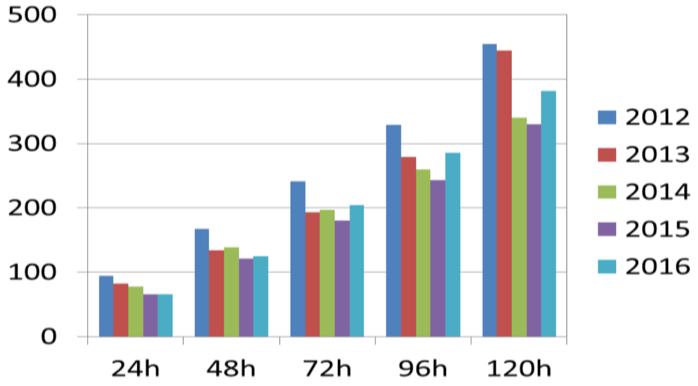


Fig.1.6. 2012-2016 CMA Official typhoon track forecast errors

1.1.3 Characterization of typhoon rainfall in China

In 2016, 22 typhoons generated over the northwestern Pacific and the South China Sea. Of them, 9 landed in or affected China. Super typhoon NEPARTAK, severe typhoon NIDA, severe tropical storm DIANMU, super typhoon LIONROCK, super typhoon MERANTI, Typhoon MEGI, super typhoon SARIKA and super typhoon HAIMA had a large impact on China’s rainfall, with the following two major features:

1) Extended rainfall coverage with enhanced intensity. In this year, typhoons have affected more than 10 Chinese provinces and municipalities, including Hainan, Guangdong, Guangxi, Yunnan, Guizhou, Fujian, Zhejiang, Jiangxi, Jiangsu, Shanghai, Anhui, Heilongjiang, Jilin and Liaoning, with a far-reaching impact. According to the statistics released by China’s Hydrological Department, severe tropical storm DIANMU brought to Lingao, part of Hainan, a record daily rainfall up to 538 mm. Super typhoon MERANTI hit a village in Taishun County of Zhejiang Province with an exceptional rainfall up to 258 mm in 3 hours that may appear only once every 100 years.

2) More rivers exceeding the warning level with rampant flush floods. The floods caused by typhoons were mainly seen in Hainan, Fujian, Zhejiang, Jiangsu and Jilin, among others. Some 60 rivers, including

the Nandu River in Hainan, the Minjiang River, the Jinjiang River and the Jiulongjiang River in Fujian, the Feiyun River in Zhejiang, the Lixia River in Jiangsu, the Taihu Lake area and the Tumen River in Jilin, reported the flush floods exceeding the warning water levels. Of them, 13 rivers, including the Mulan Creek and the Dazhang Creek in Fujian, and the Xuezuokou Creek, Xuanping Creek, Zhu River, and Yao River in Zhejiang, reported the flush floods exceeding the breaking water levels. The Tumen River in Jilin had a record flooding. In the Hainan Province, the Nandu River and the Changhua River recorded a raised water level by 8.5m-13m. In Fujian, a Baita hydrological station in Jiaoxi witnessed a water level rise by 10.8m within 16 hours. Some 20 tidal stations along the coasts reported the high tides exceeding the warning levels. A hydrological station in Dongguan of Guandong recorded an exceptional high tidal level that may appear only once every 100 years.

1.1.4 Tropical cyclones that landed in or impacted China

1) Super Typhoon NEPARTAK (1601)

Tropical storm NEPARTAK generated at 0000UTC of 3 July over the western North Pacific. It moved northwestward with a steadily enhanced intensity. It became a typhoon at 0000UTC of 5 July, and was upgraded to a super typhoon at 1200UTC of 5 July. Its intensity continued to strengthen, and gradually close to the southeast coast of Taiwan. It made landfall over Taidong, Taiwan Province of China at 2150UTC of 7 July, with a near centre wind speed up to 55 m/s and a minimum central pressure of 920hPa."Nepal" passed through the southern part of Taiwan into the Taiwan Strait. It moved northwestward, approaching the coast of Fujian Province. It made landfall over Shishi, Fujian Province at 0545UTC of 9 July, with a near centre wind speed up to 25 m/s and a minimum central pressure of 990 hPa. After landing, it turned northwest with weakened strength. It finally disappeared nearing an area bordered by both Fujian and Jiangxi.

Under the combined effects of NEPARTAK's residual clouds and the westerly system, the central and eastern part of Fujian, the central and southern part of Jiangxi, the southeastern and northeastern part of Zhejiang, the central and eastern coastal areas of Guangdong, and the northeastern part of Guangxi reported a combined rainfall from 100 mm to 220 mm during July 8-11. Putian and Fuzhou, part of Fujian, recorded a rainfall up to 250-427 mm, with a maximum hourly rainfall up to 126 mm in Putian, and a maximum 3-hour, 6-hour and 12-hour rainfall of 254 mm, 294 mm and 311 mm in Fuzhou, respectively. Meanwhile, the eastern part of Fujian reported a maximum wind force up to 8 or 9 Beaufort scales, with some localities reaching 10 or 11 scales. In addition, an array of areas in Taiwan, including Hualian, Taitung and Pingtung, registered a combined rainfall of 400-600 mm during July 7-9. Some localities in Hualian County had a combined rainfall exceeding 600 mm. The eastern and central part of Taiwan also reported strong winds up to 9-13 Beaufort scales, with the local gusts reaching 15-17 Beaufort scales in Lanyu, part of Taidong. Super typhoon NEPARTAK also brought strong winds and rainfall to Fujian, Jiangxi and Zhejiang, resulted in the suspension or delay of flights and trains in Fujian and Jiangxi. Some trunk roads were blocked. Fujian was hit the hardest, with the City of Putian reporting severe waterlogging and some townships having power outage and communications disruption.

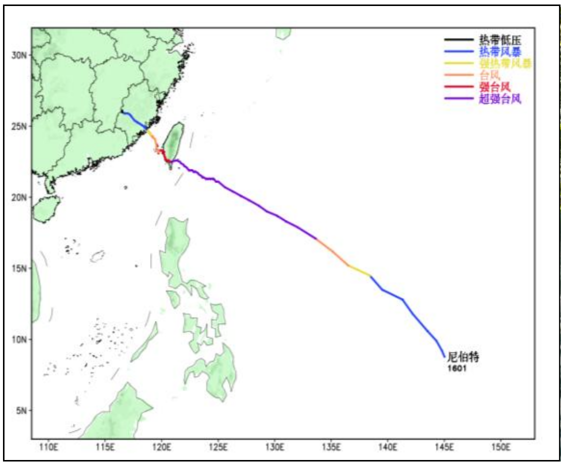


Fig. 1.7a Track of NEPARTAK

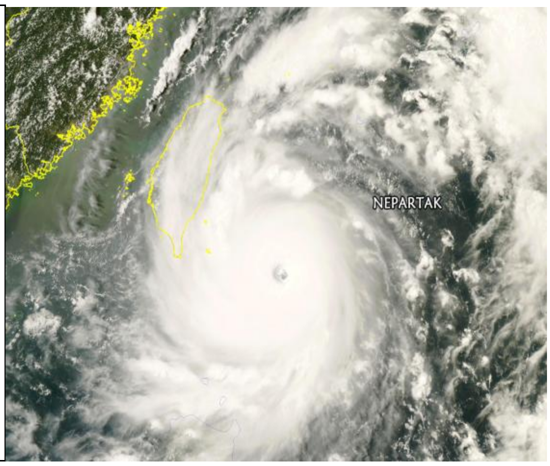


Fig. 1.7b FY3B image at 0555UTC of 7 July

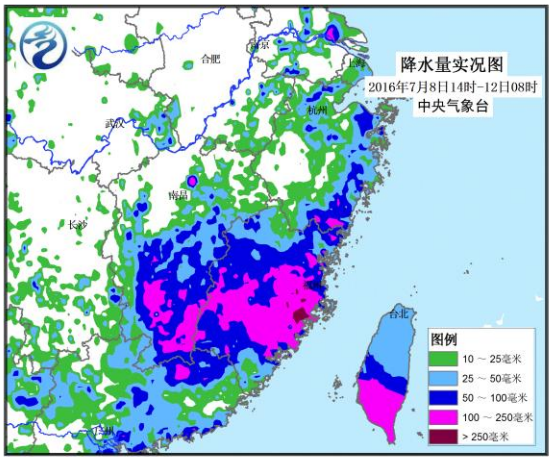


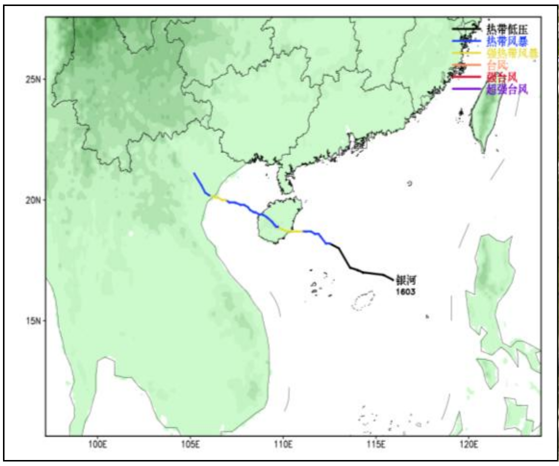
Fig. 1.7c Precipitation of NEPARTAK

Fig. 1.7d Hazards of NEPARTAK

2) Severe Tropical Storm MIRINAE (1603)

A tropical depression formed at 0900 UTC of July 25. It became tropical storm MIRINAE at 0300 UTC of July 26. It made a west-northwest movement with a steadily enhanced intensity. It became a severe tropical storm at 1200UTC of 26 July. It made landfall over Wanning, Hainan Province of China at 1420UTC of 26 July, with a near centre wind speed up to 28 m/s and a minimum central pressure of 985hPa. It landed on the northern coasts of Vietnam. After landing, MIRINAE lost its strength gradually, and vanished in the northern part of Vietnam.

Under the influence of MIRINAE, the southern part of Hainan reported a combined rainfall of 100-250 mm from July 26 to July 30. As far as the localities are concerned, Lingshui had a rainfall of 300-450 mm, and the eastern and southern part of Guangxi and the southern and central part of Yunnan had 50-100 mm with some localities reporting 150-230 mm of rainfall. Meanwhile, most part of Hainan, the southwest coasts of Guangdong and the southern costs of Guangxi reported strong winds up to 7-9 Beaufort scales, with the eastern and western coasts of Hainan having strong gales up to 10-11 Beaufort scales.



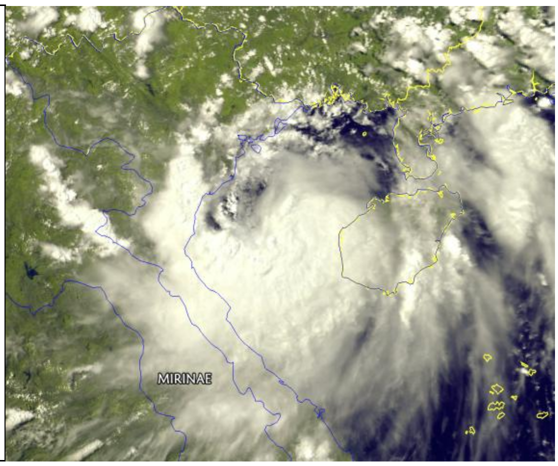
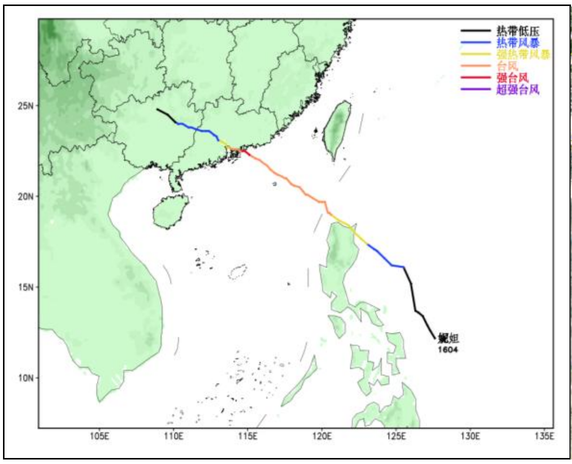


Fig. 1.8a Track of MIRINAE   Fig. 1.8b FY3B image at 0735UTC of 27 July

3) Severe Typhoon NIDA (1604)

Tropical storm NIDA generated to the east of the Philippines at 0900UTC of 30 July. It was moving northwestward, and became a typhoon in the Bashi Channel at 1500UTC of 31 July. It moved northwestward heading for the coast of Guangdong Province. It strengthened into a severe typhoon at 1800UTC August 1. It landed on Shenzhen in Guangdong Province, at 1935UTC of 1 August, with a near centre maximum wind speed up to 42 m/s and a minimum central pressure of 965hPa. After landfall, NIDA made a northwest movement, with a weakened strength. It weakened into a tropical depression in Guangxi at 1500UTC August 2.It vanished in the northern part of Guangxi.

NIDA affected on its way a range of provinces or regions, including Taiwan, Guangdong, Fujian, Hainan, Guangxi, Guizhou and Yunnan. During 1400 of August 1 – 0800 of August 4, the central and western part and the eastern coasts of Guangdong, the southeastern part of Fujian, the central and eastern part of Guangxi, the southeastern part of Guizhou and the western part of Yunnan reported a combined rainfall of 100-230 mm, with 250-319 mm in the Pearl River Delta area and the Shangchuandao area, part of Guangdong. Meanwhile, the eastern and central coastal areas of Guangdong, the eastern coasts of Fujian and the southern coasts of Guangxi reported strong winds up to 8-10 Beaufort scales, with some localities in the eastern and central coasts of Guangdong having strong gales up to 11-13 Beaufort scales. Shawei, also part of Guangdong, had strong gales up to 15 Beaufort scales (49.8 m/s). In addition, the eastern and southern part of Taiwan reported a combined rainfall of 100-268 mm during July 31- August 2, with some part of Tai Wuxiang in Pingtung County, Taiwan having a rainfall up to 490 mm.



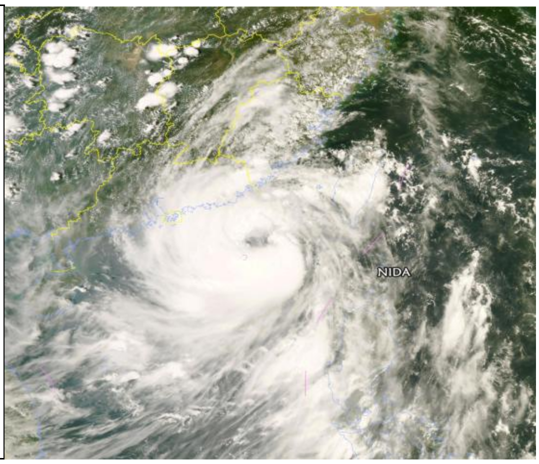


Fig. 1.9a Track of NIDA   Fig. 1.9b FY3B image at 0220UTC of 1 August

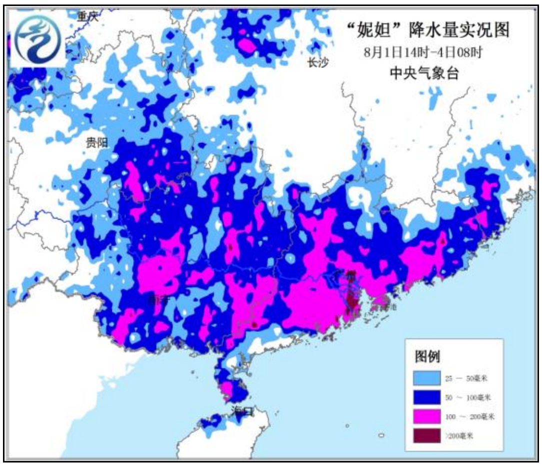
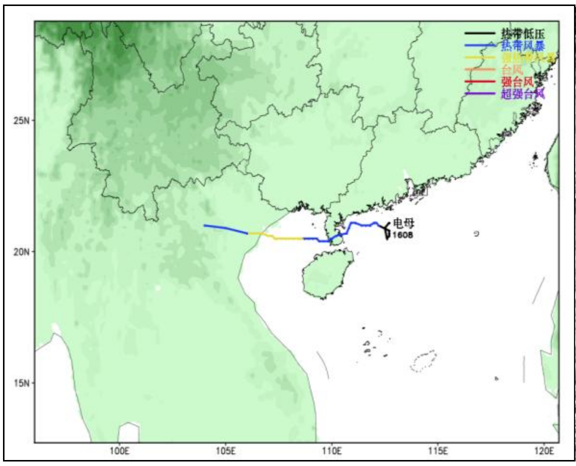


Fig. 1.9c Precipitation of NIDA　　Fig. 1.9d Hazards of NIDA

4) Severe Tropical Storm DIANMU (1608)

Tropical storm DIANMU developed at 2100 UTC of 17 August over the northern water of South China Sea. It made its way westward. It landed on Zhanjian, Guangdong Province at 0740UTC of 18 August, with a near centre wind speed up to 20 m/s and a minimum central pressure of 982 hPa. After landfall, DIANMU swept westward and crossed Leizhou Peninsula and entered Beibu Gulf, heading westward. It became a severe tropical storm over Beibu Gulf. DIANMU made landfall over northern Vietnam on 19 August. It became weakened, and vanished in the northern part of Vietnam.

Affected by DIANMU, an array of areas, including most part of the Hainan Island, the Leizhou Peninsula and eastern coasts of Guangdong, southern Guangxi and southern Yunnan, reported downpours from 0000 of August 16 to 0000 of August 20. Most part of the Hainan Island that sat on the southern flank of the typhoon reported exceptionally heavy rainfall, with the western and northern part having a rainfall up to 500-990 mm. Meanwhile, Lingao, Danzhou, Changjiang and Baisha a rainfall up to 1,000-1,083 mm. Lingao County witnessed a record combined rainfall of 732.5 mm from 2000 of August 16 to 1400 of August 18, with a record daily rainfall of 538 mm on August 17 and an hourly rainfall of 101 mm from 0900 to 1000 of August 17. Changjiang also reported a local 3-hour rainfall of 223 mm from 0800 to 1100 of August 18. During the period, most part of the Hainan Island, the southern and central coasts of Guangdong and the southern coasts of Guangxi registered a maximum wind force up to 7-8 Beaufort scales, or 9-10 scales in some localities. In the offshore areas of the port city of Fangchen, Guangxi, a maximum wind force up to 32.9 m/s was recorded.



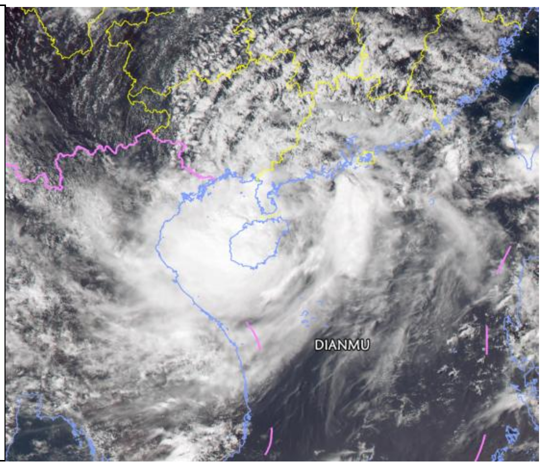


Fig. 1.10a Track of DIANMU　　Fig. 1.10b FY3B image at 0550UTC of 18 August

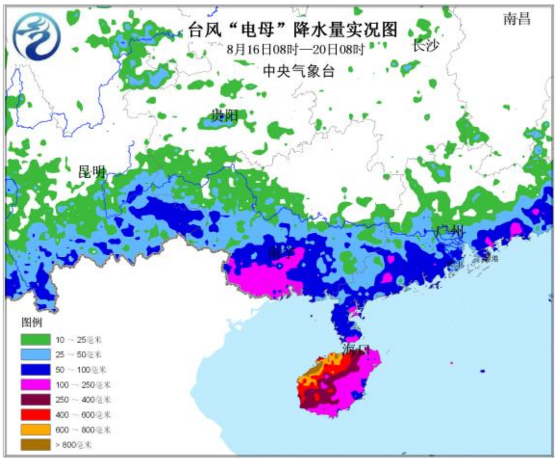
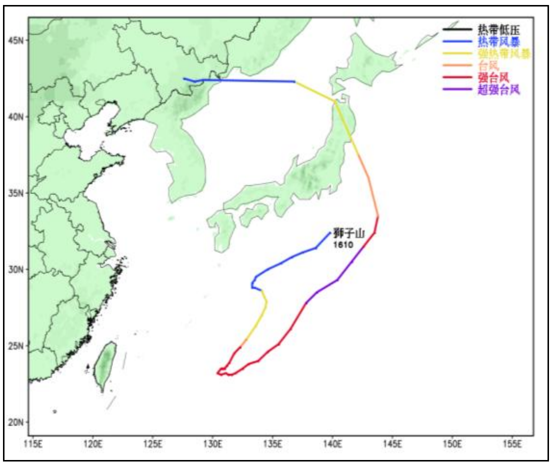


Fig. 1.10c Precipitation of DIANMU　　Fig. 1.10d Hazards of DIANMU

5）Super Typhoon LIONROCK (1610)

Tropical storm LIONROCK was formed over the western North Pacific at 1800UTC of 19 August. It moved southwestward with a rapidly enhanced intensity. It became a typhoon at 2100UTC of 23 August. It turned to northeast. Its intensity continued to strengthen. It was upgraded to a super typhoon at 0600UTC of 28 August. It then turned north-northwest, approaching the northeastern coasts of Japan. It made landfall over Japan on 30 August. It entered Japan Sea and then turned west. LIONROCK entered Yanji, Jilin province at 2350UTC of 30 August with a strong wind force up to 18 m/s. It weakened to an extratropical cyclone on August 31 in Jilin Province.

Under the combined effect of LIONROCK and an extra-tropical low, the eastern and southern part of Heilongjiang, most part of Jilin, the central and northern part of Liaoning and eastern Inner Mongolia reported a combined rainfall up to 50 mm during the period from 0600 of August 29 to 0000 of September 2. An array of areas, including Yanbian, Baishan and Tonghua of Jilin, and Hegang, Jiamusi, Qitaihe, Jixi and Mudanjiang of Heilongjiang registered a local rainfall up to 100-170 mm. Eastern Yanbian had a rainfall of 180-249 mm. Meanwhile, most part of Northeast China and the eastern part of Inner Mongolia reported a maximum wind force up to 6-8 Beaufort scales, with the northeast and southwest part of Heilongjiang and the Liaodong Peninsula of Liaoning having strong gales up to 9-12 scales.



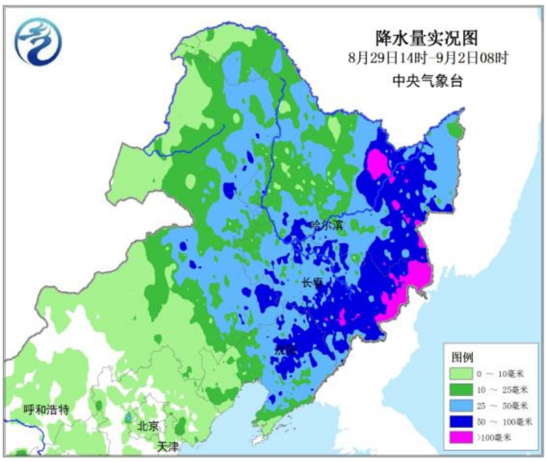


Fig. 1.11a Track of LIONROCK　　Fig. 1.11b Precipitation of LIONROCK

Fig.1.11c Hazards of LIONROCK

Fig.1.11d Hazards of LIONROCK

6) Super Typhoon MERANTI (1614)

Tropical storm MERANTI was formed over the western North Pacific at 0600UTC of 10 September. It moved west-northwestward with a rapidly enhanced intensity. It became a typhoon at 1800UTC of 11 September, and was upgraded to a super typhoon at 0300UTC of 12 September. It passed the southern sea of Taiwan, and entered Taiwan Strait. It weakened into a severe typhoon over Taiwan Strait.It then turned northwest, approaching the southern coasts of Fujian Province. It made landfall over Xiamen, Fujian Province at 1905UTC of 14 September, with a near centre wind speed up to 48m/s and a minimum central pressure of 945hPa. After landing, SOUDELOR made a gradually weakened journey across four provinces, including Fujian, Jiangxi, Anhui and Jiangsu, and ended up over the Yellow Sea.

Under the influence of MERANTI and the aftermath depression and peripheral circulations, Fujian, Zhejiang and Jiangsu reported heavy rainfall or severe heavy rainfall. The eastern part of Zhejiang, the eastern part of Fujian and some southern localities in Jiangsu registered a rainfall up to 250-400 mm, with 508 mm of rainfall in Taizhou, part of Zhejiang. Meanwhile, Taiwan's Hualien, Taitung and Pingtung areas had a rainfall up to 600-857 mm. During the period, some of the above-mentioned localities reported short-term heavy downpour with an hourly rainfall up to 50-100 mm. For example, Lianjiang, part of Fujian, had an hourly rainfall up to 133.5 mm, with Taishun of Zhejiang having a 3-hour rainfall up to 233.7 mm, and Nanan of Fujian having a 6-hour rainfall of 302 mm. Meanwhile, the eastern part of Zhejiang, the eastern part of Fujian, the southern part and coastal areas of Jiangsu reported strong winds up to 9-11 Beaufort scales. Xiamen, Quanzhou, Putian and Fuzhou recorded strong gales up to 12-14 scales, with Xiamen having gusty gales up to 16-17 scales and some localities exceeding 17 scales. The coastal areas of Quanzhou, Putian and Fuzhou had 6-10 consecutive hours of strong winds up to 12 Beaufort scales. Huian, part of Quanzhou, had 14 hours of strong winds sustained at 12 scale. In addition, the northeastern South China Sea and the northern part of Taiwan Strait reported huge waves up to 4-6 meters, with Fujian coastal waters having 3-4 m high waves. The buoys deployed near Jinmen observed 11.9 m and 4 m high solid waves at 0200 and 0600 of September 15, respectively. Meanwhile, the shorelines from the Minjiang Estuary of Fujian to the coasts of Shantou reported a raised water level by 50-290 cm due to the storm. A Shijin tidal wave station in Fujian measured the maximum raised water level at the time by 289 cm.

Affected by MERANTI, Xiamen, Quanzhou, Zhangzhou and Fuzhou in Fujian reported numerous incidences of power outage, waterlogging and housing collapse. Multiple rivers were hit by the floods and exceeded the warning level. Fujian suspended some passenger car or train operations. Some coastal airports canceled flights, and some highways were closed. The sea passenger liners between Fujian and Taiwan were all suspended due to the storm. Meanwhile, some part of Zhejiang Province reported derivative disasters, including flash floods, landslides, power outage, traffic disruption, housing collapse, among others.

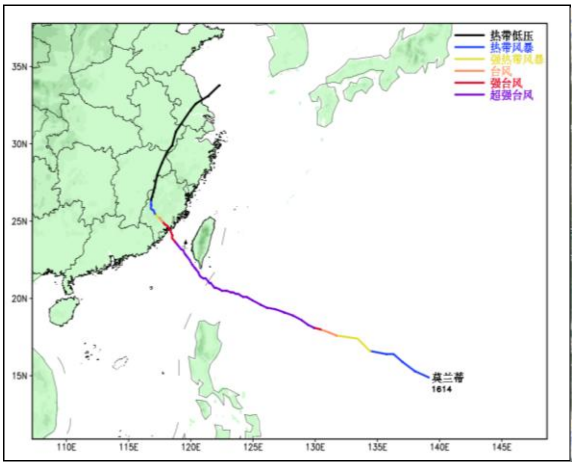


Fig. 1.12a Track of MERANTI

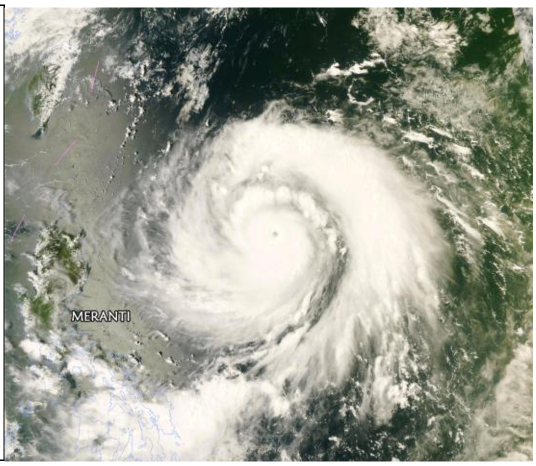


Fig. 1.12b FY3B image at 0550UTC of 12 September

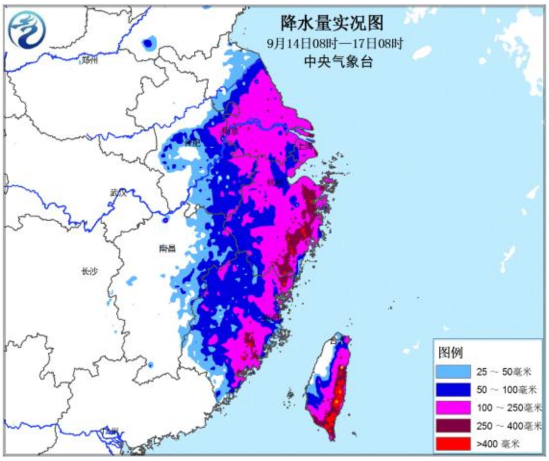


Fig.1.12c Precipitation of MERANTI

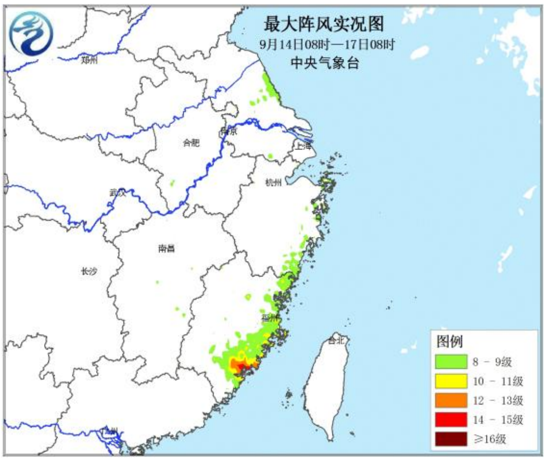


Fig. 1.12d Maximum Gust of MERANTI

Fig.1.12e Hazards of MERANTI

Fig.1.12f Hazards of MERANTI

7) Super Typhoon MEGI (1617)

Tropical storm MEGI generated at 0000UTC of 23 September over the western North Pacific. It moved northwestward with a steadily enhanced intensity. It became a typhoon at 0000UTC of 25 September, and was upgraded to a super typhoon at 1800UTC of 26 September. intensity continued to strengthen, and gradually close to the eastern coast of Taiwan. It made landfall over Hualian, Taiwan Province of China at 0610UTC of 27 September, with a near centre wind speed up to 45 m/s and a minimum central pressure of 950hPa."MEGI" passed through Taiwan into the Taiwan Strait. It moved northwestward, approaching the coast of Fujian Province. It made landfall over Quanzhou, Fujian Province at 2040UTC of 27 September, with a near-centre wind speed up to 33 m/s and a minimum central pressure of 975 hPa. After landing, MEGI made a weakened journey, and ended up over Jiangxi.

Affected by MEGI, ten provinces or cities, including Taiwan, Fujian, Zhejiang, Guangdong, Jiangxi, Hunan, Hubei, Anhui, Jiangsu and Shanghai, reported a combined rainfall up to 50-100 mm affecting an area of 452,000 and 200,000 square kilometers, respectively. MEGI, working together with cold air, brought extreme rainfall to more than 20 counties or townships in Fujian and Zhejiang. For example, five counties or townships reported the record daily rainfall with Wencheng of Zhejiang having 389mm and Shouning of Fujian having 274mm. 21 counties or townships witnessed record extreme daily rainfall in September. Fuzhou, Ningde and Putian in Fujian and Wenzhou and Lishui in Zhejiang had a combined rainfall up to 300-600 mm. Wencheng County, part of Wenzhou, received a rainfall up to 814 mm in some localities. The Taiping Mountain area in Yilan of Taiwan reported a rainfall exceeding 1,100 mm.

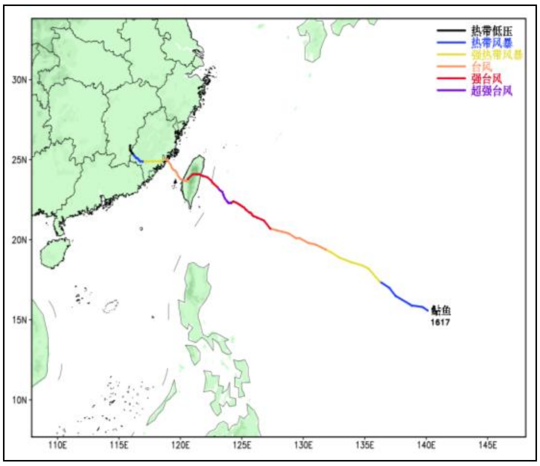


Fig. 1.13a Track of MEGI

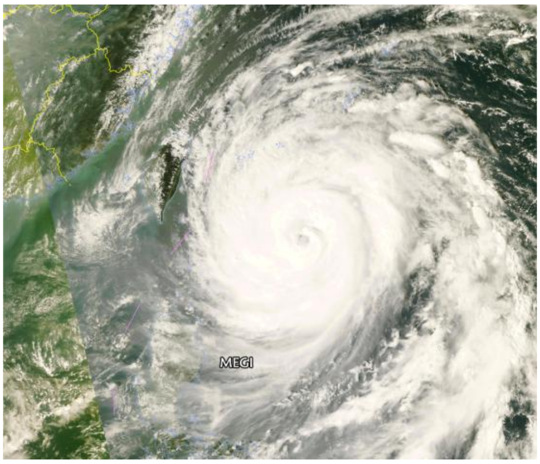


Fig. 1.13b FY3B image at 1340UTC of 26 September

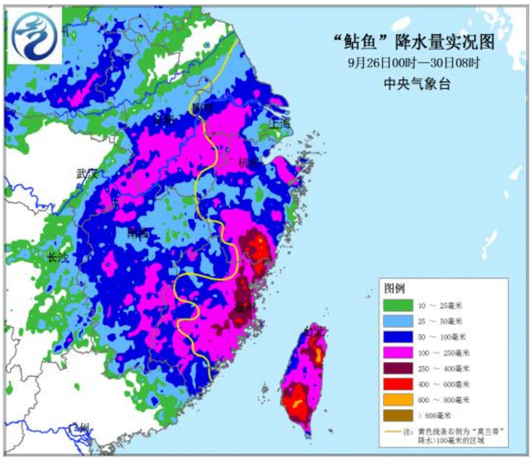


Fig. 1.13c Precipitation of MEGI

Fig. 1.13d Hazards of MEGI

8) Super Typhoon SARIKA (1621)

Tropical storm SARIKA generated at 0600UTC of 13 October over the western North Pacific. It moved northwestward with a steadily enhanced intensity. It became a typhoon at 2100UTC of 14 October, and was upgraded to a super typhoon at 1500UTC of 15 October. Its intensity continued to strengthen, and gradually close to the eastern coast of Luzon. It made landfall over the eastern coast of Luzon with a weakened strength. It entered the eastern part of the South China Sea, moving west-northwest with a steadily enhanced strength. SARIKA became a severe typhoon at 0900UTC of 17 October. It landed on Wanning in Hainan Province, at 0150UTC of 18 October, with a near centre maximum wind speed up to 45 m/s and a minimum central pressure of 960hPa. After landfall, it made a northwest movement, with a rapidly weakened strength. It moved into Beibu Gulf, approaching the coast of Guangxi Province. SARIKA made landfall over Fangchenggang, Guangxi at 0610UTC of 19 October, with a near centre wind up to 25 m/s and a minimum central pressure of 988hPa. After landing, it made a northwest movement, with a rapidly weakened strength. It vanished in the southwestern part of Guangxi Province.

Affected by SARIKA, Hainan, Guangdong, middle part and southern part of Guangxi had the cumulative rainfall 100-300 mm, during 17 -20 October. Wenchang, Qionghai, Qiongzhong, Wanning, Changjiang of Hainan province and Fangchenggang, Yulin of Guangxi had a rainfall of 330-413mm. Meanwhile, Hainan Province, the coast of Guangdong Province, the coast of Guangxi Province reported gusts up to levels 8-12. Wanhe of Hainan province had gust of levels 14(46.1 m/s).

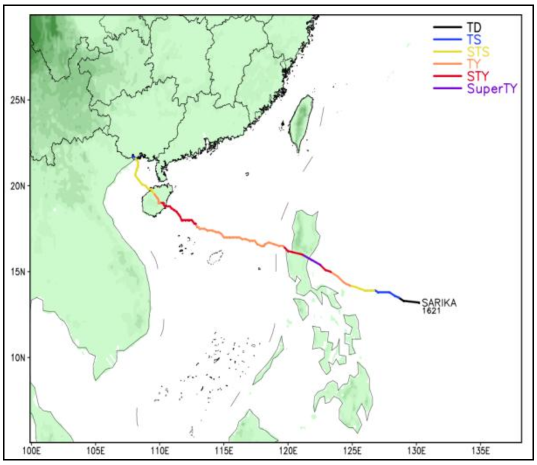


Fig. 1.14a Track of SARIKA

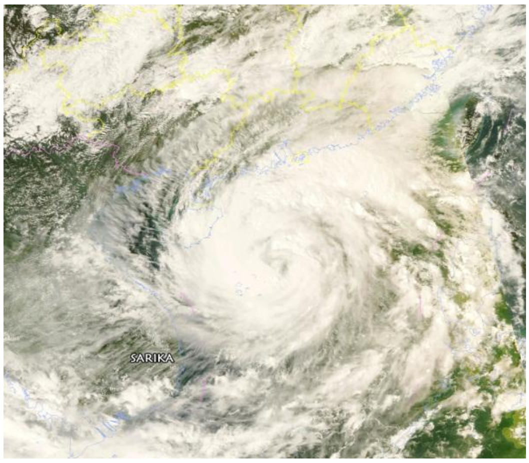


Fig. 1.14b FY3B image at 0705UTC of 17 October

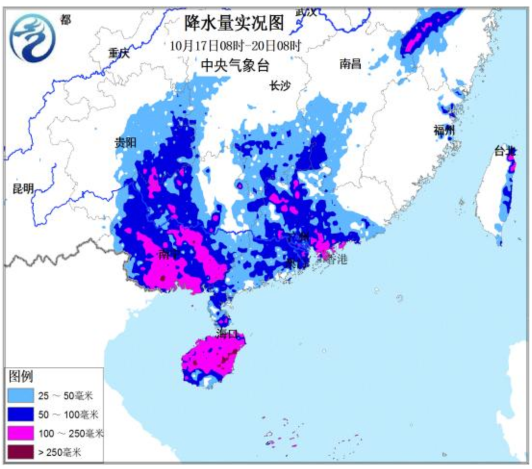


Fig. 1.14c Precipitation of SARIKA

Fig. 1.14d Hazards of SARIKA

9) Super Typhoon HAIMA (1622)

Tropical storm HAIMA generated at 0000UTC of 15 October over the western North Pacific. It moved northwestward with a gradually enhanced intensity. It became a typhoon at 0600UTC of 16 October, and was upgraded to a super typhoon at 0900UTC of 17 October. Its intensity continued to strengthen, and gradually close to the northeastern coast of Luzon. It made landfall over the northeastern coast of Luzon with a weakened strength. It entered the eastern part of the South China Sea. It continued to move northwest, approaching the eastern coast of Guangxi Province. HAIMA landed on Shanwei in Guangdong Province at 0440UTC of 21 October, with a near center maximum wind speed up to 42 m/s and a minimum central pressure of 960hPa.

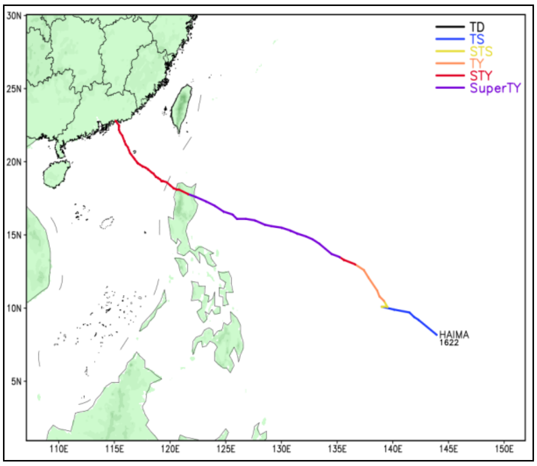


Fig. 1.15a Track of HAIMA

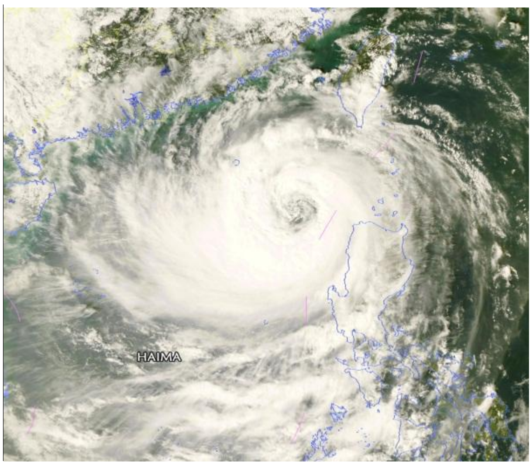


Fig. 1.15b FY3B image at 0620UTC of 20 October

1.2 Socio-economic assessment

As of October 22, 2016, 11 tropical cyclones have affected China. Of them, 8 made landfall in China. Among them, Super typhoon NEPARTAK make landfall in China in 2016, and it resulted in the most casualties, missing persons and collapsed houses. Super typhoon MERANTI was the most destructive one in 2016, which brought up the largest numbers of affected and evacuated population, damaged houses and direct economic losses.

Preliminary statistics show that these typhoons have affected 15.88 million people in 14 provinces, autonomous regions or municipalities, including Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Fujian, Jiangxi, Hunan, Guangdong, Guangxi, Hainan, Guizhou and Yunnan. In the year, typhoons have resulted in 169 deaths, 37 persons missing, 2.547 million people evacuated, 1.577 million hectares of crops affected with 183,200 hectares of croplands producing no yield at all, 181,000 houses collapsed, and 169,000 houses damaged to different degrees, with direct economic losses worth RMB 73.42 billion. Meanwhile, 0.149 million people have received emergency daily assistance due to the attack of typhoon. Fujian was a province hit the hardest by typhoon. It took up 70% of the death, missing persons and collapsed houses and 60% of the evacuated and direct economic losses caused by typhoon in the country. Zhejiang and Hainan were next to Fujian in terms of the ordeals they have suffered from typhoon.

Table 1.1 Typhoon impacts and disasters in 2016

TC Name	Landing site	Landing time	Max. wind at landing	Affected provinces	Affected Population (10,000)	Death or missing	Direct economic losses(RMB 100 million)
TD	Yangjiang, Guangdong	May. 27	14m/s	Guangdong	14.5	/	0.6
NEPARTAK	Taidong, Taiwan	Jul. 8	55m/s	Taiwan, Fujian, Jiangxi	87.4	108	126.5
	Quanzhou, Fujian	Jul. 3	25m/s				
MIRINAE	Wanning, Hainan	Jul 26	28m/s	Hainan, Guangxi Yunnan	25.0	/	3.8
NIDA	Shenzhen, Guangdong	Aug. 2	42m/s	Hunan, Guangdong，Guangxi, Guizhou Yunnan	91.2	2	11.4
DIANMU	Zhanjiang Guangdong	Aug. 18	20m/s	Guangdong，Guangxi, Hainan, Yunnan	153.1	6	31.8
LIONROCK	/	/	/	Liaoning, Jilin, Heilongjiang	144.9	/	72.1
MERANTI	Xiamen Fujian	Sep. 15	48m/s	Shanghai, Jiangsu Zhejiang, Fujian Jiangxi, Taiwan	375.5	45	317.8
MALAKAS	/	/	/				
MEGI	Hualian Taiwan	Sep. 27	45m/s	Jiangsu, Zhejiang Fujian, Jiangxi Taiwan	237.5	44	97.0
	Quanzhou Fujian	Sep. 28	33m/s				
SARIKA	Fangchenggang Guangxi	Oct.19	25m/s	Guangdong, Guangxi Hainan	357.4	1	53.0
HAIMA	Shanwei Guangdong	Oct.21	42m/s	Guangdong, Fujian	74.6	/	16.9
Total					1561.6	206	739.3

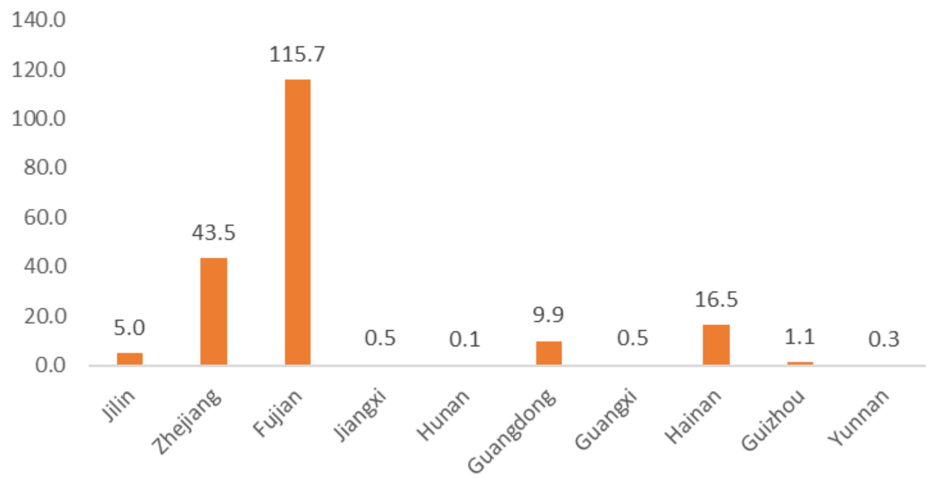


Fig.1.15. Evacuated people in emergency response to potential typhoon-induced disasters in 2016 (unit: 10,000 person times)

1.3 Regional cooperation assessment

1.3.1 China-ASEAN meteorological cooperation

The first China-ASEAN Meteorological Forum was held in Nanning, China from 11 to 12 September 2016, during the 13th China-ASEAN Expo. The theme was 'Regional Meteorological Disaster Monitoring and Joint Prevention'. The forum focused on sharing the experiences and achievements on meteorological disaster risk reduction and climate change, and on establishing the mechanism of meteorological disaster joint monitoring and prevention between China and ASEAN countries. 88 participants, from ASEAN countries and international organizations, including Vietnam, Lao PDR, Malaysia, Philippines, Singapore, Thailand and WMO, ESCAP, TCS, participated in this event. One of the major achievements of the first China-ASEAN Meteorological Forum is the approval of the Nanning Initiative on China-ASEAN Cooperation in Meteorology, which had gone through comprehensive discussions before the forum and received valuable inputs during the forum. The Nanning Initiative identified nine areas for future cooperation between ASEAN countries and China, including cooperation mechanism, meteorological observations, meteorological disaster preparedness and disaster risk management, aeronautical meteorological services, etc.

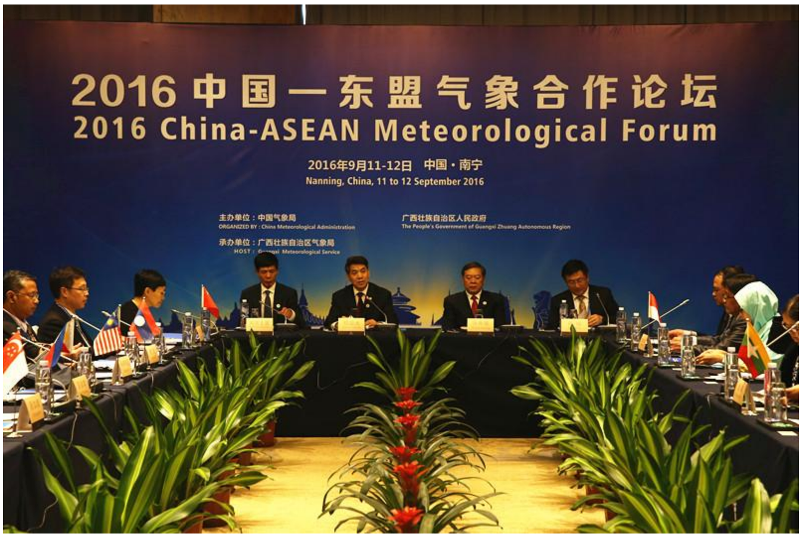


Fig. 1.16. 2016 China-ASEAN Meteorological Forum

A China-ASEAN science/technology innovation and typhoon disaster response seminar, sponsored by the Chinese Ministry of Civil Affairs, and co-hosted by the National Disaster Reduction Center and the Guangxi Zhuang Autonomous Region Civil Affairs Department, was held during September 8-9, 2016 in Nanning, Guangxi. Dozens of representatives from 8 ASEAN countries, including the Philippines, Myanmar, Indonesia, Malaysia, Vietnam, Laos, Thailand and Cambodia, and from international or regional organizations, including the United Nations International Strategy for Disaster Reduction (UNISDR) and the Asia-Pacific Space Cooperation Organization (APSCO), had an in-depth discussion with Chinese experts and scholars on S&T innovation and associated applications in typhoon disaster response. The two-day event created a dialogue and exchange platform for disaster managers, experts and scholars. The event facilitated the dialog and pragmatic cooperation between China and ASEAN countries in the area.

Fig. 1.17. China-ASEAN S&T Innovation and Typhoon Response Seminar

1.3.2 China-ROK tropical cyclone workshop

The 9th China-ROK Joint Workshop on Tropical Cyclones, sponsored by the National Typhoon Center of KMA, was held in Republic of Korea during May 16-20, 2016. Representatives from the Shanghai Typhoon Institute, Shanghai Marine Observatory, and CMA Typhoon and Marine Weather Forecast Center attended the event. The meeting, an annual event, promotes the exchanges between China and South Korea in the area of tropical cyclone research and operations, and enhances the bilateral cooperation and exchange between the two countries.

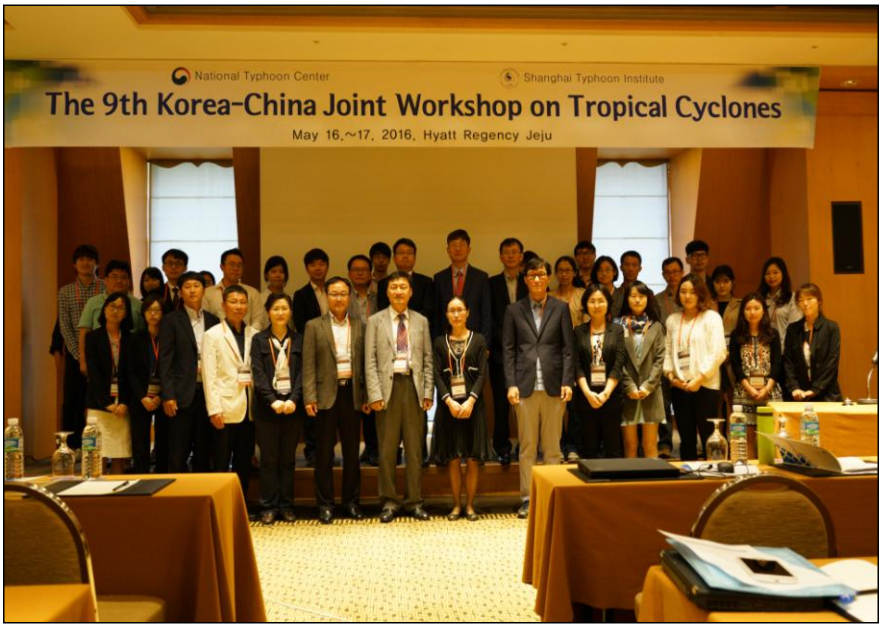


Fig. 1.18 The 9th China-Korea Joint Tropical Cyclone Workshop

1.3.3 Typhoon committee fellowship

The Tropical Cyclone Forecast and Verification Project which is included in the Meteorological

Working Group 2016 annual work plan, provides a scholarship program, with the topic of "Tropical Cyclone Generation Forecasting Techniques". The two-month (October-November 2016) scholarship program is jointly sponsored by the Typhoon Committee Trust Fund and the Shanghai Typhoon Institute. Typhoon Committee members have so far submitted their applications. Pak Sang Il and Kim Kum Song from DPRK were granted with the scholarship.

1.3.4 CMA typhoon forecaster training programme

To promote the Typhoon Committee's regional cooperation and enhance members' typhoon monitoring and early warning capability, the China Meteorological Administration staged in 2016 two rounds of international training events for typhoon forecast operation. The first 10-day training event on typhoon monitoring analysis and forecast was held during October 10-19, 2016. The trainees were lectured on a range of topics, including typhoon monitoring, analysis and forecast, numerical typhoon modeling, and storm surge and wave forecasting. The second 60-day training event will be held during November 1-December 30 to analyze the mechanisms behind the rapidly intensified typhoons recently seen in the South China Sea. Four forecasters from DPRK, Thailand and Viet Nam, including RI TU YON, YUN KYONG IL, WATCHARA JAROONSAK and LE DUC CUONG, participated in the first training event. Two others, including WIRONGRONG SUKHA from Thailand and LE DINH QUYET from Vietnam, will attend the second training event.

Fig.1.19 CMA Typhoon forecaster training programme 2016

1.3.5 International workshop on tropical cyclone

2016 International workshop on tropical cyclone organized by China Meteorological Administration will be held in regional training center of typhoon committee in Nanjing from 21th November to 2nd December, 2016. This workshop will base on theory learning and operational practice correspondingly, which could help attendances comprehend the fundamental theory of tropical cyclone and enhance the operational ability of high impacted weather forecast related to tropical cyclone.

1.3.6 Visiting of disaster preventing group

In September 26-27, 2016, according to this year's working project of typhoon committee, deputies of disaster preventing group visited China. During their visit, mechanism of disaster reduction and related technique, including reducing of disaster risks, early warning system, disaster management system and emergency actions, etc., have been discussed. The deputies also visited Ministry of Civil Affairs and operational agencies of China Meteorological Administration.

II. SUMMARY OF KEY RESULT AREAS

2.1 Typhoon forecasting technique

1. Updating typhoon track forecast method

After verifying the performance and errors of EGRR typhoon ensemble forecast, CMA forecasters blended the EGRR ensembles with EC and NCEP ensembles, and optimized TYTEC (Typhoon Track Ensemble Correction) in term of the test of weight coefficients. They also developed a dynamic positioning method that can be tailored to different forecast time range, based on their re-study of the "positioning principle" of TYTEC. Preliminary results show that the upgraded method is able to effectively curb the proportioned growth of short-term forecast errors over time. They recalculated the typhoon track forecasts in 2015 using the new TYTEC method, and narrowed down the forecast errors by 2, 5, 2, 5 and 18 km for 24, 48, 72, 96 and 120 hours, respectively, compared with the old TYTEC.

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√			√	
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.2 Typhoon numerical modeling and data assimilation

1. 3D static reference atmosphere scheme for GRAPES

To enhance the forecast accuracy of TRAMS model, a three-dimensional static reference atmosphere was introduced. The model's forecast equations based on the three-dimensional static reference atmosphere are re-deduced, and a corresponding forecasting scheme is designed. Experiments showed that the 3D model has achieved an accuracy that is noticeably enhanced compared with 1D model, with improved ground factoring and typhoon track forecast. Compared with the 1D model, the initial perturbation was sharply reduced in the 3D model, which in turn reduced the nonlinear and model integral errors to certain degree, and enhanced the overall accuracy of forecast.

2. Model dynamic and physical processes coupling and performance on typhoon forecast

To enhance the accuracy of NWP models, one not only needs a high-precision technical scheme for the dynamic and physical processes, but also has to give a due consideration to the coupling between the dynamic and physical processes. GRAPES model is applied with a complex physical feedback to be the right side of the implicit equation for solving the Helmholtz equation, in an attempt to cuts down interpolation errors. The Helmholtz equation filters out some inconsistent information to enhance the accuracy of prediction. Meanwhile, the coupling scheme filters out some noticeable disturbing information. Experiments showed that doing so enhanced the model's stability and prediction accuracy, desirable for typhoon track forecast.

3. New GRAPES_TCM version

The new version of GRAPES_TCM, developed by the Shanghai Typhoon Institute, has made a series of upgrades on data assimilation, vortex initialization, dynamic framework and physical process. It was put into operation in 2015, and achieved track prediction errors of 71.2km, 134.8km and 210.5km for 24, 48 and 72 hours.

4. Typhoon ensemble forecast experiment based on physical process uncertainty

Built on the GRAPES_TCM model, the experiment was designed to mirror the uncertainty of typhoon physical process through changing convection and boundary layer parameters. Three convection parameterization schemes (KF, BMJ and SAS) and two boundary layer parameterization schemes (MRF and YSU) were integrated to generate 6 ensemble members. In the experiment, the method of building the track ensemble on different members using their corresponding weighted average, and the method of correction before doing arithmetic average for intensity ensemble were applied.

5. Enhanced vortex initialization

The dynamic typhoon vortex initialization in WRF mesoscale model is enhanced, and a corresponding T-RAPS system is developed. The T-RAPS system has been applied to make real-time typhoon forecasts at the Chinese Academy of Meteorological Sciences. The forecast products serve as a reference for the National Meteorological Center making its typhoon forecast. In addition, Chinese scientists are currently working on the new applications of high-resolution land data and ocean-atmosphere coupled models.

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√	√			
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.3 Typhoon research

1. Helicity-based tropical cyclone boundary layer parameterization and associated applications

To enhance numerical models' capability of simulating the helical structures of tropical cyclone's boundary layer, a helicity based new planetary boundary layer height parameterization scheme was developed. It is planned to introduce the scheme in the WRF model's (YSU) PBL parameterization to study the landing typhoon MORAKOT that occurred in 2009.

2. Impact of southern and northern hemispheric SST gradients on the typhoon numbers over the northwestern Pacific.

The physical mechanisms are analyzed that the temperature gradients between the southwestern and northwestern Pacific warm pools to impose an effect on the frequency of tropical cyclones appeared on the western North Pacific. They developed a physical model allowing the SST gradient to suppress the tropical cyclone generation on the western North Pacific in a normal or abnormal manner. The model has been used to forecast tropical cyclone activities on the western North Pacific in 2016. Currently the second climate change concerning the western North Pacific typhoons is undergoing assessment, and the report will be released in the near future.

3. Cloud microphysical scheme comparison in typhoon modeling

The WSM6 and WDM6 cloud microphysical schemes are employed to simulate Typhoon RAMMASUN (2014). The result tells that the two schemes had relatively small discrepancies on track simulation, though the WDM6 scheme was weaker in intensity simulation with an abnormally high probability for heavy precipitation but unusually low probability for weak precipitation. Both schemes are able to reflect the evolution of raindrop spectrums over the development of typhoon.

4. Impact of Taiwan terrain induced meso-scale systems on typhoon rapid intensification

A high-resolution numerical simulation of Typhoon MORANTI (2010) is performed. Results show that in the course of typhoon entering the Taiwan Strait, the terrains in Taiwan may induce meso-scale vortices in the Strait that would in turn encourage the formation of mesoscale turbulence wave trains, enhancing the vertical movement of typhoon circulations and feeding kinetic energy to the high-level part of typhoon, facilitating the rapid development of typhoon.

5. New method to forecast the precipitation for landing tropical cyclones

QPF of 8 typhoons which affected the South China during the period of 2012-2014 is tested based on the LTP_DSEF model. Results show that the LTP_DSEF model performed noticeably better compared with the dynamic model in predicting the heavy rainfall brought by tropical cyclones.

6. National Key Basic Research and Development Program

China National Key Basic R&D Program, or the 973 Program, made in August 2016 a mid-term summary and assessment of the project "Observation, Prediction and Impact Assessment of the Fine Structures of Landing Typhoons". The project has since 2015 launched a range of field experiments to collect the observations of five typhoons, including CHAN-HOM (2015), MUJIGAE (2015) and NEPARTAK (2016). The project has developed multi-scale ensemble and variational assimilation techniques, and has made laudable progresses in cloud microphysical and convective parameterization. It studied the fine structures of typhoons and associated evolution mechanisms, and obtained a number of new research results. Meanwhile, it has created a research and demonstration platform for high-resolution

numerical typhoon prediction, and put the dynamical interpretation of typhoon wind fields in operation, providing technical support for the operational forecast of the fine structures of typhoons and associated wind and rainfall distributions.

KRA =	1	2	3	4	5	6	7
Meteorology	√			√			
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.4 Journal of tropical Cyclone research and review

J. Tropical Cyclone Research and Review has been published in 15 issues that carried 101 papers authored by the scientists from the Typhoon Committee member or non-member countries, including Australia, India, Oman, Germany and Russia. The publication has enjoyed an increased number of contributors.

Statistics released by the journal website show that readers from more than 100 countries or regions have downloaded the full text of the papers published by the journal. The full-text download reached some 79,000 times, or 782 times per paper. The data indicates that the journal has attracted more readers' attention. The journal is currently being assessed by SCI. According to an annual implementation plan, the journal will invite Mr. Kamol Promasakha na Sakolnakhon from the Meteorological Service of Thailand and Dr. Chen Yi-Leng of the University of Hawaii to be this year's guest editors stationed in Shanghai.

KRA =	1	2	3	4	5	6	7
Meteorology	√						
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration	√						

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2.5 Ocean observing system and observation experiments

1. Ocean observing system

By September 2016, China National Marine Meteorological Observatory (NMMS) has 393 island based automatic weather stations (AWS, offshore platforms), 200 gale observing stations, 52 ship based AWS, 35 weather observing buoys, 35 weather radars, 10 upper air sounding stations, 17 wind profilers, 103 GNSS weather stations, 37 lightning stations, 6 ground wave radars, and 3 storm surge stations.

2. Ocean drifter observer based typhoon observation experiment

A range of marine observing experiments using the prototype Ocean Drifter Observer are launched in several sea areas during June-August 2016. The experiments collected the real-time data of Typhoon NIDA (2016). Thanks to the experiments, more means of collecting real-time typhoon data is available now, and the capability of observing typhoon's process is enhanced.

3. Preliminary assessment of typhoon rocket sounding experiment

A successful launch of the first experimental typhoon sounding rocket was made at 2300 of October 23, 2015. The rocket aboard with multiple drop-sounding instruments was launched to collect the data of typhoon MUJIGAE at a height 11 km above the ground. The preliminary assessment made in 2016 show that the real-time data sent back to the ground control by the drop-sounding instruments in the 100-km central area of typhoon MUJIGAE are reliable.

4. Observing experiment for severe typhoon NIDA

During the period of July 31-August 3, 2016, the Chinese Academy of Meteorological Sciences, Nanjing University, and CMA Guangzhou Institute of Tropical Marine Meteorology, jointly launched a field experiment to observe severe typhoon NIDA that landed on the coasts of Guangdong Province (Figure 2.1). The large-scale field observing experiment was conducted across 8 cities, including Guangzhou, Shanwei, Maoming, Qingyuan, Huizhou, Shenzhen, Zhuhai and Yangjiang. In addition to the conventional observing instruments, an array of advanced equipment were involved, including Ka and C-band dual polarization radar, wind profiler, microwave radiometer, laser raindrop spectrometer, land and sea air observing system, marine droplet observing system, among others. The evolution of the fine structures of Typhoon NIDA during landing and associated wind and rainfall distributions and air-sea interactions are observed in this program.

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.6 GF-4 satellite applied in typhoon monitoring

GF-4 satellite was put into operation on June 13 of 2016. The satellite is a geostationary orbiting spacecraft with the highest resolution, covering an area of 7,000 km × 7,000 km that includes China's territories and the surrounding areas. It is designed with a spatial resolution up to 50 meters for the visible channel. GF-4 played an important role in monitoring the typhoons occurred in 2016, effectively enhanced China's meteorological emergency service capabilities. In monitoring and predicting super typhoon NEPARTAK in July and severe typhoon NIDA in August, GF-4 collected the refined data revealing the cloud structures and associated evolution, especially the development of small-scale cloud clusters, which helped meteorologists to improve the accuracy of typhoon intensity estimation and rainfall prediction. It provides the finest ever satellite observations to study the structure and development of typhoon.

KRA =	1	2	3	4	5	6	7
Meteorology	√						
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.7 CMACast and WIS enhancement

1. CMACast

CMAcast, built on the DVB-S2 standards, makes an important part of CMA's domestic and international communication systems. It broadcasts real-time meteorological data to the Asia-Pacific region through YW-4 C-band transponders and inexpensive single-ended satellite receivers at a rate of 70Mbps. CMACast broadcasts a range of products, including global ground/upper air observations, satellite based remote sensing data and products, numerical prediction products and radar products. Of the satellite data are FY-2E/F/G, FY-3B/C, Meteosat 7/10, Metop A/B, NOAA 19, GOES-13/15, Jason-2, TERRA/AQUA, among others. Meanwhile, CMACast also serves as a regional center for GEONET Cast in Asia. It has data exchange and re-broadcasting operations with EUMETSAT and EUMETCast. As of September 2016, CMACast has 2,688 registered Chinese users and 24 registered users in other Asia-Pacific countries. The combined application of CMACast and MICAPS can greatly enhance user's application of CMACast data.

2. WIS

In 2016, Beijing's four GISC and CMA product centers (DCPC) have run smoothly, providing an array of products, including FY satellite products, T639 global mesoscale NWP products, T213 ensemble forecast products, typhoon ensemble forecast products, and global/Asian climate watch products in a volume of 148,254 metadata to DPRK, Mongolia, Nepal, Pakistan, Hong Kong, Macau and other WMO members in the Asia-Pacific region. It has 114 registered users who are fed with 890GB of data on a daily basis. China Meteorological Administration has since September 2015 provided CMA Cast, MICAPS and WIS related training to a number of WMO Members, including Pakistan, DPRK, Myanmar, Laos, among others on WIS implementation and data access, played an active role in promoting the implementation of WIS in Asia.

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR							
Training and research		√					
Resource mobilization or regional collaboration	√	√					

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2.8 Strategies and actions for typhoon preparedness of CMA

1. **Enhanced decision-making meteorological service**. China Meteorological Administration (CMA) Decision-Making Meteorological Service Center provided timely special meteorological reports and meteorological disaster early warning bulletins to the government agencies concerned, helping them combat a range of typhoon events occurred in the year, including super typhoon NEPARTAK, severe typhoon NIDA, super typhoon MERANTI, Typhoon MEGI, among others.

2. **Early warning service**. CMA released typhoon and heavy rain early warning information in a timely manner (Table 2.1). The warning information on geological disaster, storm wave, storm surge, power outage, road traffic disruption, ship wreck disaster is also reached to the public through the national emergency early warning information release system. CMA provides early warning services for 29 early warning coordinating government agencies. Meanwhile, meteorological departments at provincial, autonomous regional and municipal levels have provided early warning services to 200 million persons-times.

3. **Enhanced emergency response and coordination**. CMA has worked with the government agencies responsible for civil affairs, water resources, homeland and transportation, sharing with them the information on emergency events. It also shared through the sharing mechanism the warning information with government agencies supplying safety supervision, education, agriculture, fishery and maritime affairs, providing strong support for safety supervision, risk avoiding, mass evacuation, maritime search and rescue, among others. The efforts have achieved fine results in disaster prevention and mitigation

KRA =	1	2	3	4	5	6	7
Meteorology	√	√	√				
Hydrology							
DRR		√		√			
Training and research							
Resource mobilization or regional collaboration							

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2.9 South China Sea typhoon monitoring and early warning platform

CMA has basically completed the preparation of a webpage devoting to South China Sea typhoon monitoring and early warning at the end of 2015 (http://www.nmc.cn/typhoon/). The webpage was upgraded in early 2016 to provide more information and products on typhoon observation, forecasting and early warning for the northwestern Pacific and South China Sea regions, quantitative precipitation forecast and strong convection monitoring for the South China Sea and the Indochina Peninsula, among others. The users in the countries or regions adjacent to the South China Sea may download these professional typhoon monitoring and early warning products in a timely manner. In addition to the conventional typhoon track products and alerts, CMA also prepares and releases typhoon generation probability forecasting products, gridded maritime strong winds products, Indochina Peninsula QPF index, EFI index forecast and strong convection monitoring index products for the South China Sea and adjacent areas. The platform has been put on-line serving the latest typhoon season. It provides severe weather forecast and early warning information to the South China Sea and adjacent areas, promoting information sharing and exchange with the neighboring countries, in an attempt to jointly combat typhoon attacks and enhance people's disaster prevention and mitigation capabilities.

KRA =	1	2	3	4	5	6	7
Meteorology	√	√					
Hydrology							
DRR							
Training and research							
Resource mobilization or regional collaboration	√	√					

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2.10 Typhoon disaster risk management and effectiveness

1. Disaster information reporting and release

China's national natural disaster management system made a further upgrade and enhancement of its functions, management, remote control and decision-making support capabilities. Up to date, China has 27 provinces that have an online disaster reporting system down to the township or community levels, with an increase of 58.8%. The 5-level (province, city, county, township and village) disaster reporting APP has some 32,000 users (Figure 2.2). Thanks to the application of China's Beidou satellite navigation system, China has achieved refined location-oriented information collection and communications. The collected disaster information would be released to some 5,700 subscribers to the public WeChat webpage of China Disaster Reduction (Figure 2.3).

2. State Oceanic Administration research project facilitates typhoon disaster statistics

A research project working on marine disaster statistics is completed in collaboration with the State Oceanic Administration, which has rolled out a typhoon and storm surge disaster statistical system, and a range of standards, indexes and operational rules for statistical marine disaster reporting. The efforts have laid a ground for establishing a standardized and well-regulated disaster statistics system for the marine sector.

3. Effective emergency response and rescue

In 2016, China National Disaster Reduction Committee and the Ministry of Civil Affairs initiated three rounds of level-Ⅳ emergency response to typhoon NEPARTAK, MERANTI and MORAKOT. Authorities concerned dispatched three working groups to the disaster stricken areas helping the localities with the relief work (Figures 2.4 and 2.5). Up to date, statistics show that the Ministry of Civil Affairs and the Ministry of Finance have allocated RMB 75 million to the relief and resettlement.

4. 24-hour disaster watch and real-time disaster information release

A 24-hour disaster watch is launched before and after typhoon landing. It collected disaster information through disaster reporting hotline (+86-10-52829999) and the National Natural Disaster Management System. It collected some 3,025 disasters reports from provincial, municipal and county authorities in combating 8 typhoons that affected China. It released about 100 issues of disaster information reports to the government agencies concerned, and sent some 100 case messages to the public though the official webpage.

5. Timely early warning and loss assessment

The National Disaster Reduction Committee and the Ministry of Civil Affairs separately issued three warning responses to typhoon NEPARTAK, NIDA and MERANTI. They issued emergency circulars to the central relief supplies, and provided guidance to the local civil affairs operations for their relief efforts. Meanwhile, 13 rounds of typhoon disaster early warning and loss assessment, 2 rounds of remote sensing monitoring and evaluation are carried out. The efforts made reference available for decision-makers to work on assessment and emergency materials dispatch.

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR	√	√					
Training and research							
Resource mobilization or regional collaboration							

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2.11 On-site information acquisition project endorsed by NATIONAL KEY R&D PROGRAM

A special project to collect on-site disaster information was endorsed in July 2016 by the NATIONAL KEY R&D PROGRAM. The project will address a range of difficulties encountered in collecting on-site disaster information, including difficult and slow access to information and delay in information processing. It will introduce an array of advanced technologies, including Unmanned Aerial Vehicles (UAVs), sensors, communication equipment and information processing equipment, and work on the key and core technologies for small common load, stable high-speed transmission, efficient real-time processing, accurate and rapid extraction, among others. It will strive to collect reliable on-site disaster information under complicated weather conditions and hazardous environment through the UAV platform in an all day, all-weather and fast manner. It will also work on the fast information transmission, processing, extraction and mapping, providing reliable real-time on-site disaster information to the decision makers. The project is jointly sponsored by 6 organizations, including the Chinese Academy of Sciences Changchun Institute of Optics and Fine Mechanics, Ministry of Civil Affairs National Disaster Reduction Center and Chinese People's Public Security University, and will be jointly implemented by 17 institutions in 4 years.

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology							
DRR	√	√					
Training and research							
Resource mobilization or regional collaboration							

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2.12 Typhoon forecast and early warning for small and medium sized rivers and reservoirs

1. Key small and medium-sized reservoir scheduling database and enhanced typhoon forecast and warning

In 2016, the Ministry of Water Resources Hydrology Bureau created a database to collect the scheduling information of some 1,000 small and medium-sized reservoir in five key coastal areas in southeastern China, in an attempt to secure a safe rainwater capacity for the reservoirs before the arrival of typhoon.

In addition, it strengthened in 2016 flooding forecasts for the typhoon-affected areas. Authorities in the areas are supposed to issue rolling forecasts for the water situation based on real-time rainfall conditions and numerical weather forecasts. The flood forecasts will be shared with higher-level authorities concerned through a sharing mechanism. Up to date, the hydrological departments in the affected areas have issued more than 1,000 real-time flood forecasts, effectively supported the flood control efforts at all levels.

2. Early warning models for data-scarce small and medium-sized rivers and urban waterlogging

In 2016, the Ministry of Water Resources Hydrology Bureau enhanced the development of early warning models for data-scarce small and medium-sized rivers and urban waterlogging. It has developed and perfected a distributed hydrological model with physical mechanisms based on soil hydrodynamics. The model has been put in use making forecasts for data-scarce small and medium-sized rivers. Meanwhile, it has developed an urban waterlogging early warning model taking into account the existing urban drainage network system. The model has been put in use in the selected cites on an experimental basis.

KRA =	1	2	3	4	5	6	7
Meteorology							
Hydrology	√	√					
DRR							
Training and research							
Resource mobilization or regional collaboration							

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2.13 China-Vietnam strengthening typhoon forecast consultation

At the 11th Joint Working Group Session on Cooperation in Meteorological Science and Technology between China and Vietnam held in May 2016, China and Vietnam agreed to enhance their collaborations in predicting weather, including typhoon, heavy rain, cold air, drought and other extreme events. During the period of August 15-17, the South China Sea witnessed rampant monsoon activities that sustained an east-west tropical convergence zone in its northern flank. The zone may easily become a tropical depression or a tropical storm at any time. By the hotline, Chinese and Vietnamese forecasters discussed for 3 consecutive days the development of tropical clouds, their future paths and evolving trends and the possible impact on precipitation. The real time telephone consultation meeting between China and Vietnam facilitates the sharing of technical information and judgments between typhoon forecasters of the two countries, enhancing their typhoon forecast accuracy and service capability.

KRA =	1	2	3	4	5	6	7
Meteorology		√					
Hydrology							
DRR							
Training and research	√	√	√				
Resource mobilization or regional collaboration							

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2.14 CMA tropical cyclone forecast skill training

In 2016, the Chinese Academy of Meteorological Sciences and China Meteorological Administration Training Center jointly staged a training event on tropical cyclone. The event focuses on the application of theoretical knowledge and new methods/data in typhoon forecasting, in a bid to enhance forecasters' application capability.

1. Summer school for typhoon dynamics

A summer school event on typhoon dynamics, sponsored by the Chinese Academy of Meteorological Sciences State Key Laboratory for Disaster Weather, was held during August 10-19, 2016 in Beijing. Prof. Wang Yuqing from the University of Hawaii, Prof. Zhang Dalin from the University of Maryland, Prof. Zhang Fuqing of Pennsylvania State University, Prof. Tan Zhemin of Nanjing University and Prof. Chen Lianshou from the Chinese Academy of Meteorological Sciences lectured at the event. Some one hundred researchers and graduate students from domestic meteorological departments, universities and research institutions participated in the event.

2. Advanced Nowcasting Techniques workshop

An advanced nowcasting techniques workshop, sponsored by the China Meteorological Administration Training Center, was held during January-September of 2016 in Beijing. 33 participants heard a range of lectures aligned for the purpose, including basic radar principles, image quality control, basic radar image recognition, thunderstorm potential forecasting, thunderstorm classification, typical severe storm structures radar products/algorithms, and nowcasting techniques for gales, short-duration heavy rainfall and hail.

KRA =	1	2	3	4	5	6	7
Meteorology		√					
Hydrology							
DRR							
Training and research	√	√	√				
Resource mobilization or regional collaboration							

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Attached figures

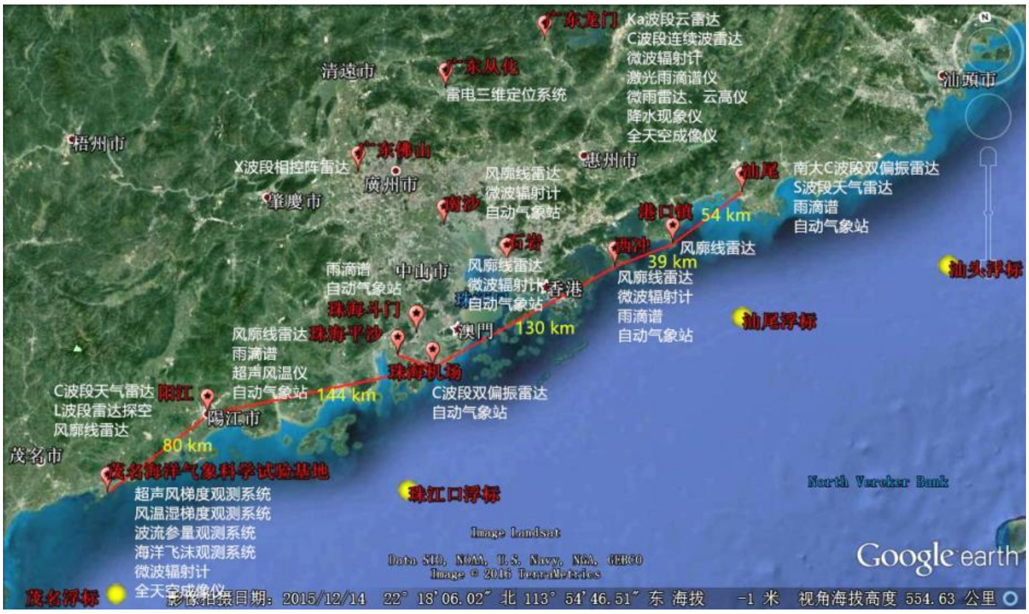

Fig. 2.1 An experiment staged to observe Super typhoon NIDA

Fig. 2.2 5-level disaster data collection APP for province, municipality, county, township and village

Fig. 2.3 China Disaster Mitigation through its WeChat public page

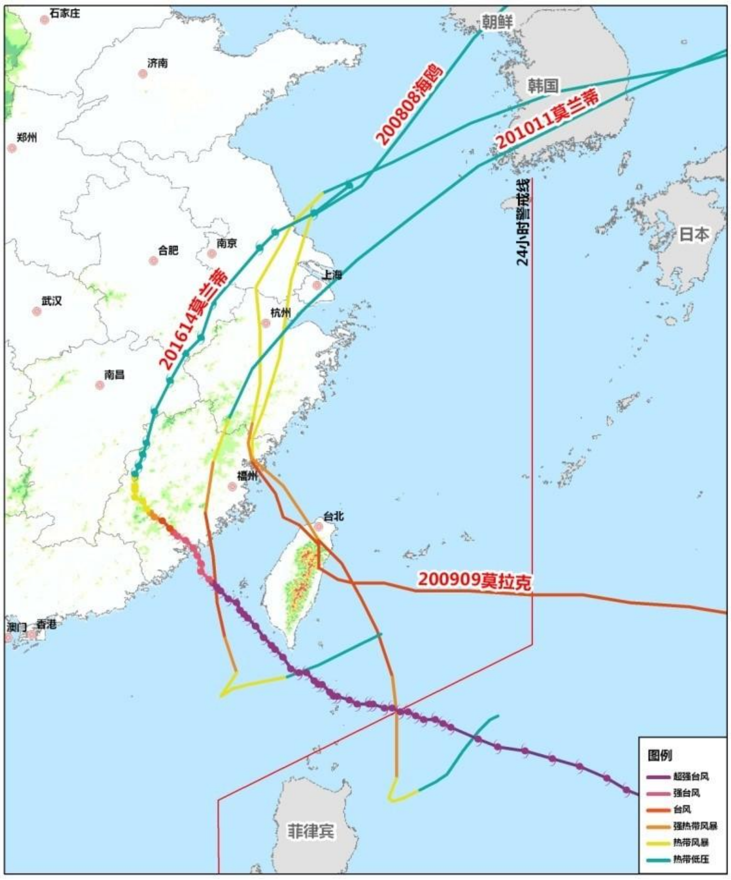

Fig. 2.4. A quick assessment of super typhoon MERANTI’s tracks

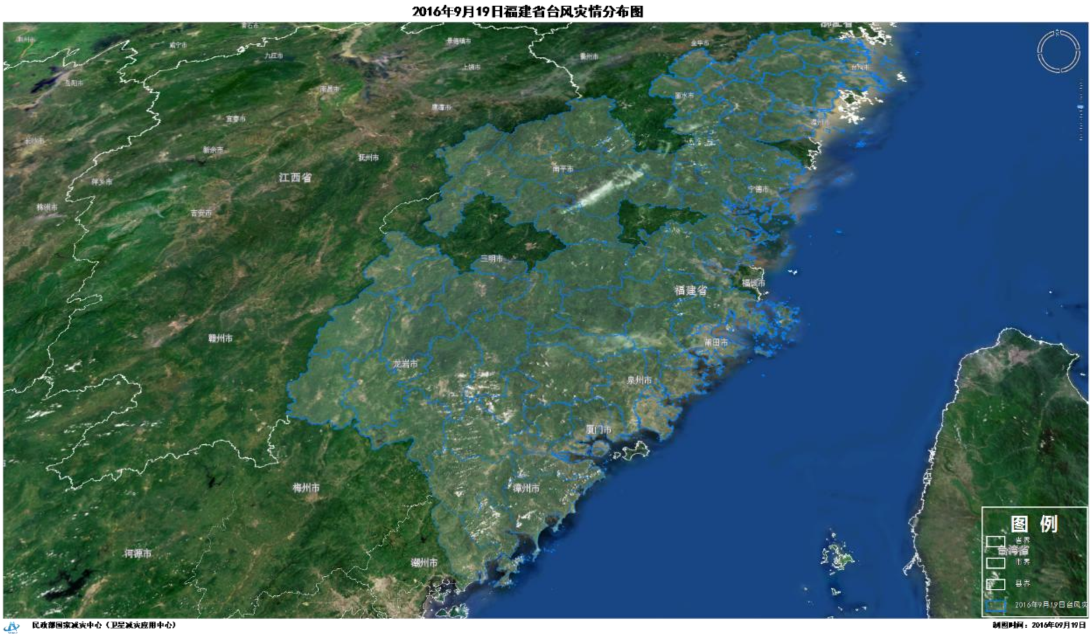

Fig. 2.5 Remote sensing picture showing the damages caused by super typhoon MERANTI in Fujian

TC No.	TC Name	Warning category	Emergency Response to typhoon Disasters CMA
1601	NEPARTAK	**Orange**	Level-III warning issued at 1100 of 6 July. Upgraded to Level-II at 0830 of 7 July. Level-II dismissed at 0800 of 10 July.
1603	MIRINAE	**Blue**	Level-IV warning issued at 1200 of 26 July. Level-IV dismissed at 1800 of 28 July.
1604	NIDA	**Red**	Level-III warning issued at 1000 of 31 July. Upgraded to Level-II at 0800 of 1 August. Level-II dismissed at 0800 of 3 August.
1608	DIANMU	**Blue**	/
1610	LIONROCK	**Blue**	/
1614	MERANTI	**Red**	Level-III warning issued at 0830 of 13 September. Upgraded to Level-II at 1800 of 13 September. Level-II dismissed at 0800 of 16 September.
1616	MALAKAS	**Yellow**	Level-IV warning issued at 1000 of 17 September. Level-IV dismissed at 1200 of 18 September.
1617	MEGI	**Orange**	Level-III warning issued at 0830 of 26 September. Level-III dismissed at 0830 of 29 September.
1618	CHABA	**Blue**	/
1619	AERE	**Blue**	/
1621	SARIKA	**Red**	Level-III warning issued at 0830 of 16 October. Upgraded to Level-II at 1630 of 16 October. Downgraded to Level-IV at 0900 of 19 October.
1622	HAIMA	**Red**	Upgraded to Level-III at 0800 of 20 October. Further to upgraded to Level-II at 1830 of 20 October.

Table 2.1 CMA emergency responses and warning services in 2016